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Reference No. 53-1

PREDICTING WING LIFT LOADS, PBY-6A
FROM ACCELEROMETER MEASUREMENTS

By

Given A. Brewer

January 1953

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                              Director

PREFACE

With the loan, through the courtesy of the Office of Naval Research, of a PBY-6A aircraft to this project for the measurement and investigation of atmospheric turbulence and convection, numerous problems have arisen concerning the use of this airplane as a meteorological tool and concerning its instrumentation. These problems center around the detection of atmospheric motions, such as drafts and gusts, from an extended object which is itself in motion through the air. Much information concerning the aero-dynamics and structural characteristics of the aircraft itself has been needed in order to interpret reliably the readings of the meteorological instruments that are mounted on and within it.

For these purposes a consulting engineer, Given A. Brewer, has been retained by the project. The present report constitutes the results of one of the very essential studies of the aircraft made by him.

PREDICTING WIND LIFT LOADS,
PBY-6A FROM ACCELEROMETER MEASUREMENTS

Abstract

The study of gust distribution and characteristics in the atmosphere is of importance in both of the separate fields of aeronautics and meteorology. To utilize properly an airplane for air sounding missions it is necessary to instrument the airplane so that the gust forces acting upon the aircraft may be determined by suitable instruments within the fuselage. The most convenient method for determining dynamic wing loads is through the use of a fuselage accelerometer and associating recording apparatus. Shifting span-wise lift distribution in accelerated flight, wing over-travel, flexibility of the accelerometer supports, and fuselage rotation all create false accelerations at the instrument. A test program was carried out to determine the correlation between wing lift loads and accelerometer measurements on the PBY-6A airplane. Wing lift loads of the aircraft were determined by means of electric strain gauges on the lift struts while two electric accelerometers fastened within the fuselage were used to record translational and rotational acceleration.

The aircraft was flown at various angles of attack in steady state and observations made of lift strut strains. A second flight in which the aircraft was put through a number of maneuvers comprising chandelles and pull-outs at high speed was made imposing accelerated loadings upon the wing. Readings of lift strut strain

and fuselage acceleration were oscillographically recorded during the accelerated maneuvers. Analysis of these data indicates that accelerometers maintained in the fuselage between the bracketing bulkheads adjacent to the airplane center of gravity may be used to predict wing lift loads within the range of .8G and 2.1G. This study indicates that the span-wise lift distribution is not altered by changes in angle of attack within the range of 4-1/2 to 12.8° or by acceleration loadings up to 2.1G.

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INTRODUCTION.

The study of gust distribution and character in the atmosphere is of importance in both of the separate fields of aeronautics and meteorology. Airplanes equipped with suitable recording instruments have been used over the past 20 years[1] to determine the frequency and magnitude of gust occurrence in the atmosphere. The information gained through these past experiments has been the basis of aircraft structural design criteria[2,3,4] both in this country and abroad. The Woods Hole Oceanographic Institution is one of the U.S. research organizations continuing investigations into the structure of atmospheric turbulence.

The Geophysics Branch of the Office of Naval Research has secured for the Oceanographic Institute a PBY-6A airplane, Navy 46683; for use in the exploration of atmospheric phenomena. To properly use this aircraft for sounding missions it was necessary to determine the correlation between acceleration measurements within the fuselage and aerodynamic forces acting upon the wing. The effects of wing whip or fuselage motions independent of the wing will give rise to accelerometer readings that are in no way related to the air loads acting upon the wing. Accordingly an experimental program was carried out wherein wing lifting loads were measured simultaneously with fuselage accelerations, permitting correlation of these two quantities.

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PROCEDURE.

The wing lift struts of the PBY-6A airplane provide a means for the determination of wing lift loads. Assuming that the wing structure remains elastic throughout the loading regime and that the spanwise pressure distribution is also constant, the wing lift struts will carry a constant proportion of the wing lift load. Consequently by cementing electric strain gages to the struts these gages may be used to determine the portion of the total wing lift load carried by the struts. Under the conditions limited by the assumptions previously stated, the strain gages will yield readings correlating linearly with the aerodynamic load on the wing.

Eight electric strain gages of the SR-4 A-6 type were cemented to the leading and trailing edges of the lift struts as shown in the Figure 1. By locating these gages at these points of greatest curvature the possibility of error in reading, due to the presence of secondary strains, was eliminated. To eliminate thermal components of strain a non-stressed dummy D-1 was buried within the insulation covering the other gages on the left front strut. Lead-in wires from each of these gages were brought in through the fuselage skin to the recording instruments within the cabin. A considerable portion of the strut on both sides of the point of gage attachment was thermally insulated and both gages and insulation were waterproofed, the purpose being to reduce gage electrical drift.
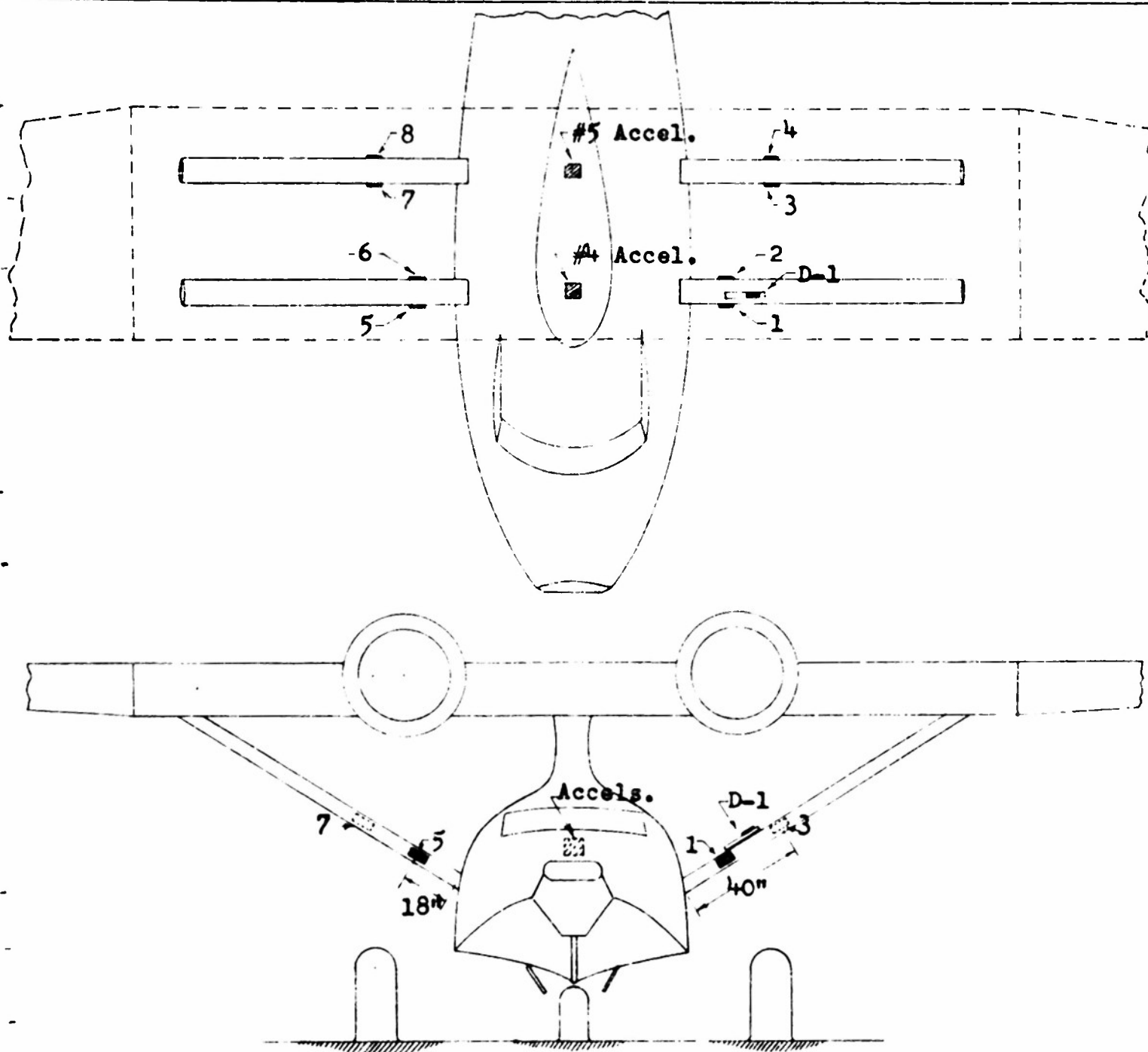
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FIGURE 1.   SKETCH OF PBY-6A, NAVY 46683 SHOWING LOCATION OF
STRAIN GAGES ON LIFT STRUTS AND ACCELEROMETERS
IN FUSELAGE, 9-8-52.

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Two electric accelerometers of the fluid damped mass type[5] as
manufactured by the Statham Laboratories, were attached to struct-
ural members within the fuselage. The 6 G accelerometer was
fastened to the aluminum alloy conduit running across #4 bulkhead
ring and the 12 G accelerometer was clamped to the #5 bulkhead
ring, see Figure 1.

The recording instruments were placed upon one of the canvas bunks
in the crew's quarters between bulkheads #4 and #5. The leads from
the strain gages on the lift struts and the cables from the accel-
erometers were brought through the fuselage to the instrument
location and secured. The entire system was grounded by clipping a
lead from the amplifier to the fuselage structure.

Photographs of the installation and instruments are carried in the
appendix no. 1 of this report.

FLIGHT I.

The individual strain gages were connected separately into a Baldwin
SR-4 twenty channel switch which in turn was connected to a Baldwin
Strain Indicator model L. The dummy D-1 was used to compensate all
gages. The state of stress in the struts while the aircraft was at
rest on the ground was arbitrarily taken as the zero reference.
Assuming that the struts, at this low stress level, are as rigid
in compression as in tension; the strut stress due to dead weight

will be a constant and cancel out from incremental measurements.

The airplane's gross weight was determined and with the instruments connected to the strut gages, as previously described, take off was accomplished at 1:42 PM on 9-8-52. While airborne the aircraft was flown at constant altitude with variations in speed so that the effect of chordwise center of pressure shift could be evaluated. Strain gage observations were made at each value of angle of attack and recorded, see Table I. These observations permitted detection of spanwise pressure distribution changes, if any, with variations in angle of attack. The airplane was landed at 3:15 PM and the ground zero reference gage readings observed.

FLIGHT II

This second flight was programmed to investigate the spanwise lift distribution in accelerated flight and to observe the relationship between lift strut strains and fuselage accelerometer readings.

The strain gages on the front lift struts were put in series-parallel and inserted electrically into a wheatstone bridge, the other legs comprising 300 ohm non-inductive advance wire resistors. Similarly the gages of the two rear struts were put into a second bridge. The accelerometers each contain a balanced four legged bridge. The four bridge circuits were then connected into a four channel carrier amplifier, as sketched in the Figure 2, in turn connected to the first four channels of a recording oscillograph.

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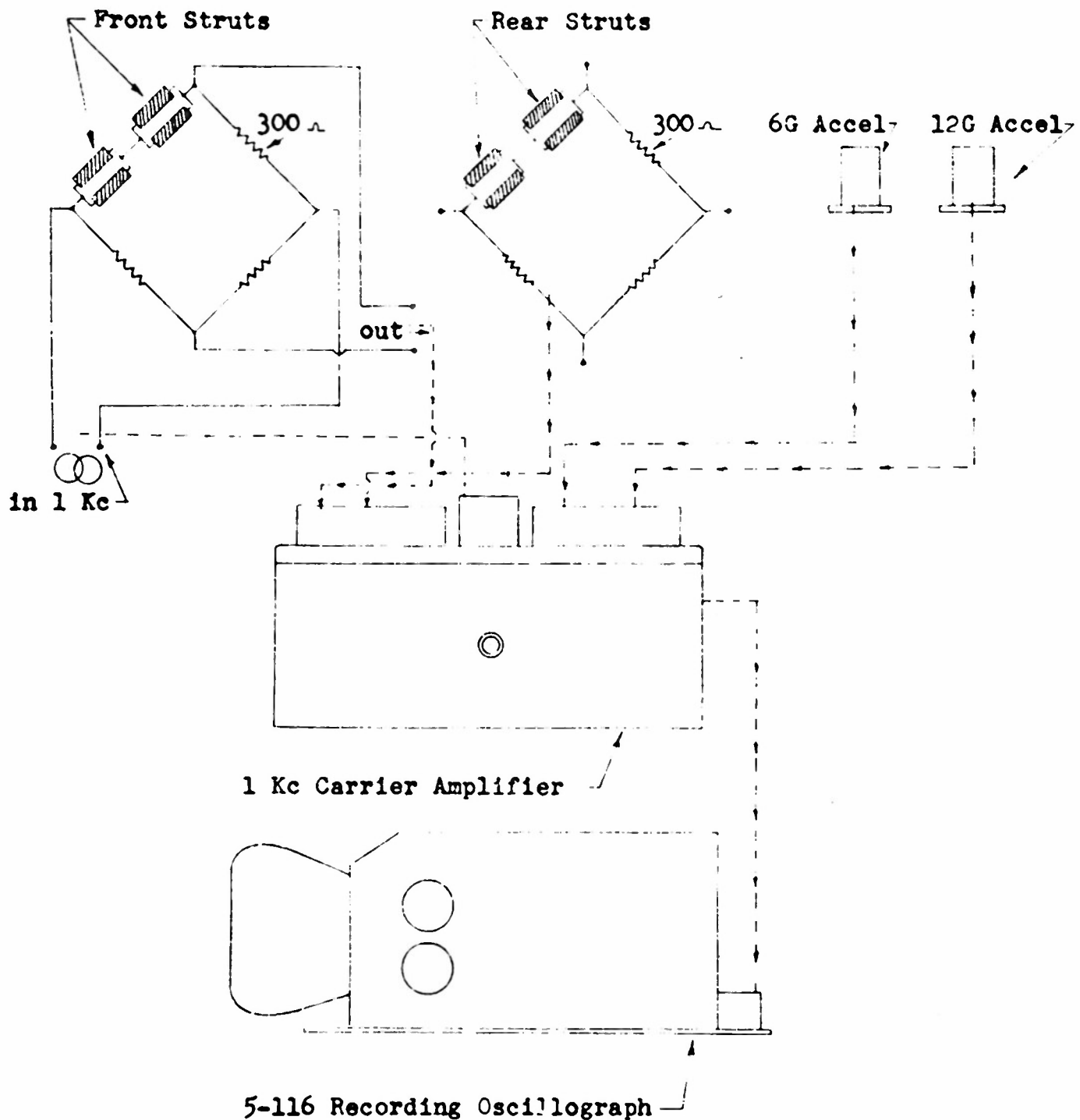Front Struts   Rear Struts

300 ~   300 ~   6G Accel   12G Accel

out

in 1 Kc

1 Kc Carrier Amplifier

5-116 Recording Oscillograph

FIGURE 2.   BLOCK DIAGRAM OF INSTRUMENTS USED FOR RECORDING STRUT STRAINS AND FUSELAGE ACCELERATIONS, 9-8-52.

FLIGHT II CONT.

With the instruments connected as described take off was accomp-
lished at 4:29 PM on 9-8-52. In flight the airplane was put through
a number of maneuvers including pull ups and chandelles. During
each of those accelerated flight maneuvers bridge output readings
from the struts and accelerometers were simultaneously recorded.
The amplifier was adjusted so that a 1 G acceleration would produce
approximately the same trace deflection for each of the four channels.
The aircraft was landed at 4:58 PM and the ground zero reference
taken for drift determination. An analysis of the data appears in Table II

The 110 volt power system of the aircraft was used to power the
recording oscillograph and its galvanometer lamps. Due to an
unnoticed drop in voltage of the 110 volt system on the ground the
ground reference traces are weak but legible, see Appendix no. 2.

RESULTS.

The data recorded during flight I are presented in the Table I. Exami-
ning the lift strut data reveals the fact that the average lift strut
stress is virtually the same over the range of attack angle investi-
gated. For the strut stress to remain constant requires that the
spanwise lift distribution must also be constant over the speed
range investigated and under steady state flight conditions. The divi-
sion of load between the front and rear struts changes but little
with variations in angle of attack showing that the wing is suffici-

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TABLE I

FLIGHT I, NAVY PBY-6A 46683; 9-8-52. STRUT STRAINS VS ANGLE OF ATTACK.

SPEED	0	0	104 K*	110 K*	100 K	90 K	80 K	70 K	0
TIME	1:32 PM	1:40	1:44	2:22	2:34	2:38	2:43	2:46	3:17
α	-	-	-	4.5°	5.8°	8.3°	9.2°	12.8°	-
P. ALT.	66	66	-	2100'	5220'	5200'	5200'	5240'	-
TEMP.C°	-	-	-	11	9	9	9	9	-
GAGE				Strain Micro inches/inch.					
1	-70	-90	495	520	540	540	532	525	0
2	-64	-59	406	411	431	443	441	441	0
3	-130	-110	540	540	530	520	512	495	0
4	-110	-100	290	300	290	300	290	270	0
5	-72	-72	538	538	558	558	550	536	0
6	-63	-58	422	412	437	452	442	440	0
7	-117	-92	563	593	560	566	543	543	0
8	-110	-100	290	310	305	310	310	302	0
Average front strut			466	471	492	498	491	486	0
Average rear strut.			421	436	422	424	414	402	0
Average front and rear.			443	453	456	461	453	444	0
Average strut stress psi.			4560	4670	4700	4750	4670	4580	0

NOTES:
1. Flight I, 9-8-52. Take off 1:42PM EDT; land 3:15 PM. Gross weight = 32408 lbs cg @ 256 inches @ 2:34 PM. cg limits 242.5 to 259, hydrodynamic; 260.7" aft limit of controllability in flight.

2. * Rough air, averaged swing of needle of Strain Indicator.

3. Temperature compensating aluminum alloy channel in left front lift strut leading edge. Covered with rubber tape and corrugated cardboard.

4. Barometric pressure, 30.48" Hg, Providence, R.I. 4:26 PM EDT.

5. Used 3:17 PM ground readings for zero reference.

6. α = angle of attack degrees.

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RESULTS CONT.

ently rigid in torsion to resist appreciable warping with chord-
wise center of pressure shifts. The pylon connecting the main wing to
the fuselage presents a more rigid path to the wing torsion couple
than does the lift strut configuration hence the strut stresses, for
all practical purposes, are solely a function of wing bending moment.
Even if the wing were not so rigid in torsion the average of the
front and rear struts would be solely a function of wing bending.

The data recorded during the accelerated flight program are presented
in the Table II. The increments of strut strain recorded during take
off are very nearly the same as those previously observed at 1 G
during unaccelerated flight. The greatest acceleration reached was
2.09 G's during a chandelle to the right @ 152 Knots. The two accel-
erometers read virtually alike during all of the maneuvers indicating
that accelerations due to pitching were negligible. The accelerometers
also read alike during light turbulence encounter.

Assuming that spanwise lift distribution is the same for accelerated
as for steady state flight, the lift strut strains resulting from
various maneuvers may be predicted from the data recorded during
Flight I. The computed lift strut stress is obtained by multiplying
the average fuselage acceleration observed, by the average strut
stress observed at 1 G. These calculations are presented in the
Table III together with the measured values of average strut stress.

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TABLE II
FLIGHT II, PBY-6A, NAVY 46683; 9-8-52
ACCELERATIONS & STRUT STRAINS.

NO.	MANEUVER	No.4 B'hd Accel. G's	No.5 B'hd Accel. G's	Front Struts Strain	Rear Struts Strain
1215	Calibrate 150000 ohms, four channel	.97	1.82	980	980
1216	On ground, 4:25 PM EDT.	1.00	1.00	0	0
1217	Take off 4:29 PM	1.00	1.00	457	460
1218	Pull up @ V_1 = 152 Knots, @ 2100'	1.88	1.94	787	820
1219	Pull up @ V_1 = 152 K, end @ 58 K.	1.72	1.74	735	811
1220	Chandelle left @ 150 Knots.	1.85	1.87	810	888
1221	Chandelle right @ 152 Knots.	*	2.09	894	986
1222	Two needle turn left 180° @ 110 K.	1.60	1.60	698	685
1223	Two needle turn right 180° @ 105 K. 4:44 PM	1.67	1.65	728	734
1224	Mild turbulence 4:50 PM @ 800' Alt V_1 = 112 - 108 K. Max. values.	1.22	1.21	569	571
1224	Mild turbulence, min. values	.85	.82	420	414
1226	On ground 4:58 PM EDT.	1.00	1.00	0	*
1228	Calibrate 150000 ohms four channels	.97	1.82	980	980

NOTES:
1. Gross weight = 31496 lbs, cg @ 254".

2. Oscillograph paper speed: .48"/second; 2.08 seconds/inch.

3. Galvanometer brightness: 3.5.

4. Accelerometer on #4 bulkhead drifted .043 G's; accel.on #5 bulkhead drifted .13 G's during test. Overall response decreased 6.6% average during test. Drift and response loss proportioned each run.

5. * Off paper edge.

6. Double needle turns averaged with planimeter over 14.3 second period, for run 1222, 1.60 G's corresponds to a turning rate of 11.8 deg/second. Airplane actually was being flown at 12°/sec.

7. Planimetering 15 seconds of #4 accelerometer, run 1224 = 1.041 G

8. 6-G Statham Accel. #4 bulkhead; 12 G on #5 bulkhead.

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TABLE III
FLIGHT II, NAVY PBY-6A 46683; 9-8-52

MEASURED & COMPUTED LIFT STRUT STRESSES VS LOAD FACTOR

RUN NO.	AVE. LOAD FACTOR G's	AVE. STRUT STRESS - Psi	COMPUTED * STRUT STRESS
1217	1.00	4720	4515
1218	1.92	8280	8670
1219	1.73	7960	7810
1220	1.86	8745	8400
1221	2.09	9690	9450
1222	1.60	7110	7230
1223	1.66	7540	7500
1224	1.22	5870	5510
1224	0.84	4300	3795

NOTES: 1. * Computed from 1 G steady state flight measurements
ie: Flight I, Gross weight = 32408 Lbs. cg @ 256"
average strut stress = 4650 psi; reduced to 31496 lbs
equals 4515 psi.

2. Load factor is average of two accelerometer readings,
one at #4 the other at #5 bulkhead. Strut stress is
the average of all four lift struts, assume $E = 10.3 \cdot 10^6$.

3. Values given for runs 1222 and 1223 average of plan-
imeter readings over a 14.3 second period.

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RESULTS CONT.

The theoretically predicted and observed values of lift strut stress
have been plotted against load factor on the Figure 3. The Figure 3.
indicates that a linear extrapolation of the strut stress at 1 G
will fall through the test points established during accelerated
flight. The linear relationship between strut stress and load factor
indicates that the spanwise lift distribution remains constant during
accelerated flight at least up to 2.1 G's. Despite the poor aero-
dynamic form of the fuselage it does not noticeably affect the dis-
tribution of lift along the wing throughout the ranges in speed,
angle of attack and acceleration investigated. It seems evident that
wing lift loads may be accurately predicted from fuselage accelerometer
readings in the case of the PBY-6A airplane.

WATER COLUMN VS ELECTRIC ACCELEROMETERS.

During Flight II, fuselage accelerations were also recorded by means
of a simple water column accelerometer located on the table within
the navigation compartment of the airplane. Accelerations from this
instrument were recorded by means of a direct writing inked pen.
The chart made by the water accelerometer has been analyzed and
compared to the data from the electric accelerometers, this compari-
son is carried in the Table IV and shows good correlation.

WING WHIP.

At this date it has been impossible to obtain any engineering infor-
mation on the PBY airplane from either the manufacturer or the present
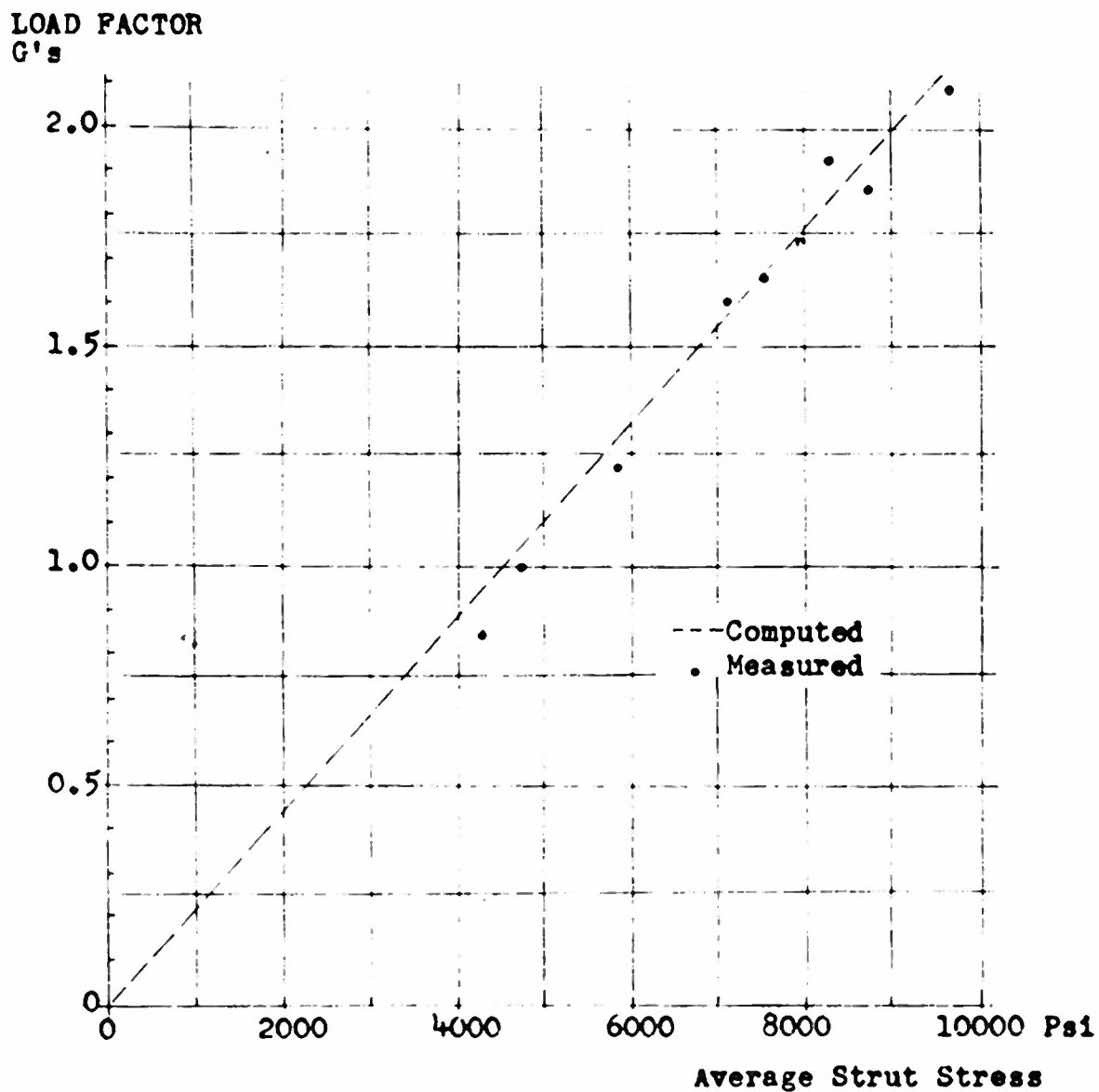
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LOAD FACTOR
G's

FIGURE 3.   DYNAMIC LIFT STRUT STRESS, MEASURED VS COMPUTED.
FLIGHT II PBY-6A NAVY 46683; 9-8-52.

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TABLE IV

COMPARISON WATER COLUMN WITH ELECTRIC ACCELEROMETERS, 9-8-52

RUN NO.	AVE. ELECTRIC	WATER COLUMN	% DIFFERENCE
1218	1.92	1.77	8
1219	1.73	1.66	4
1220	1.86	1.76	5
1221	2.09	1.90	9
1222	1.60	1.52	5
1223	1.66	1.60	4
1224	· 1.22	1.22	0
1224	0.84	0.88	5

NOTES: 1. Above data from analysis of records taken during
Flight II on 9-8-52.

2. Electric accelerometer readings are the average of
the readings from the Statham 6 G model R-6-350 and
the Statham 12 G model AR-12-250. Recorded on
Consolidated Engineering oscillograph type 5-116
driven by four channel 1 Kc carrier amplifier.

3. Water column accelerometer direct coupled to ink
recording pen.

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WING WHIP CONT.

licencee, the C.H. Babb Co. Consequently the fundamental bending
frequency of the wing is not known and therefore cannot be identi-
fied among the various frequencies observed in the oscillograph
traces. Acceleration errors due to wing whip in a strut braced wing
should be less likely as compared to the case of a cantilevered wing.
Moreover it seems certain that wing over travel would produce fuse-
lage reactions of opposite sign to those resulting from the strut
loads consequent on wing whip. Wing whip then should be identifiable
from the oscillograph records wherein the strut strain traces should
exhibit oscillations of greater amplitude than the corresponding
oscillations in acceleration. Examination of the oscillographic
records of appendix no. 2 indicates that, except for take off, the
strut and accelerometer traces correlate in both amplitude and fre-
quency. It appears that for this airplane, errors in accelerometer
readings due to wing whip are negligible, over the range investigated.

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APPENDIX NO. 1
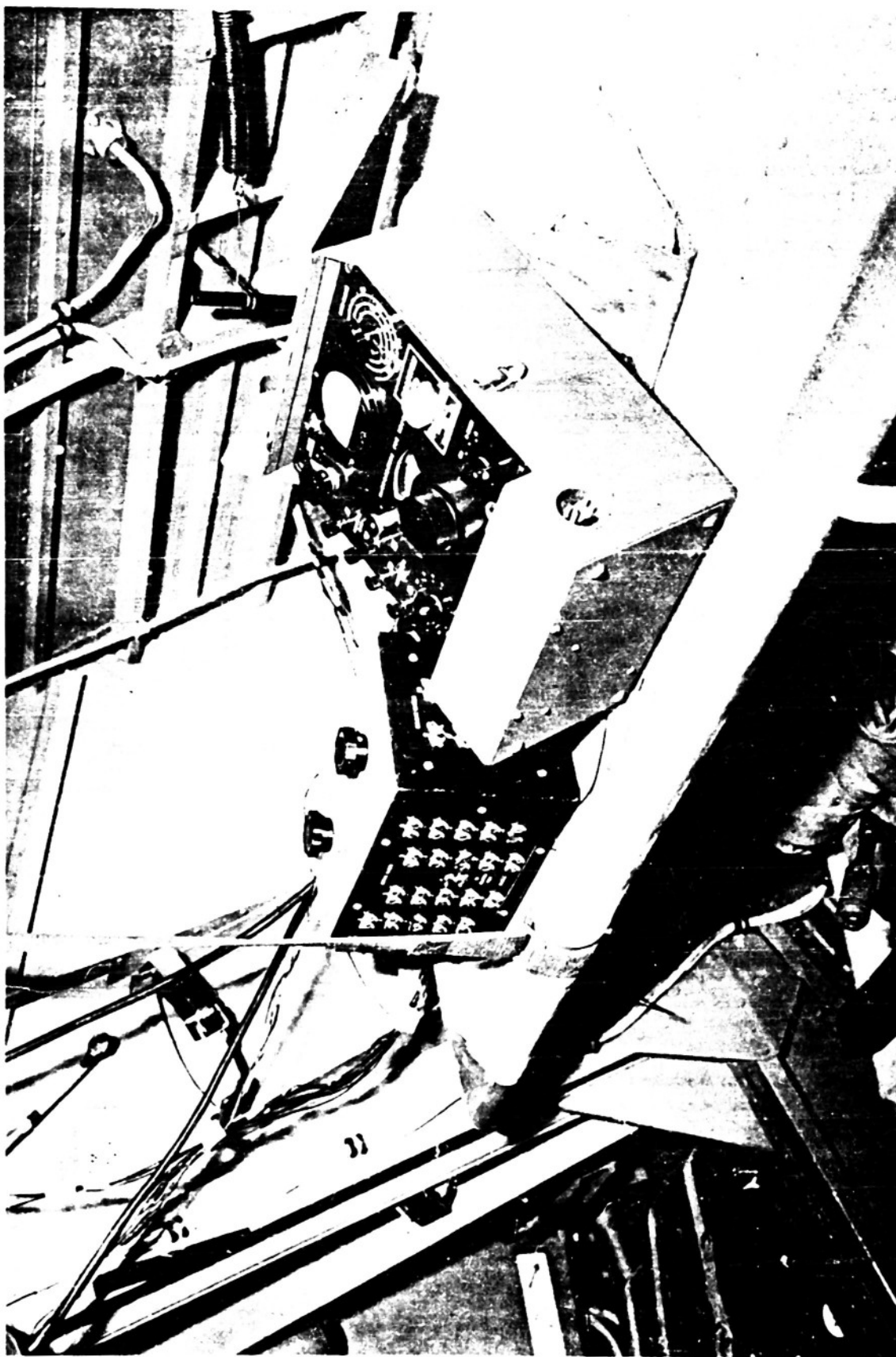
PHOTOGRAPHS OF AIRPLANE AND TEST INSTALLATION
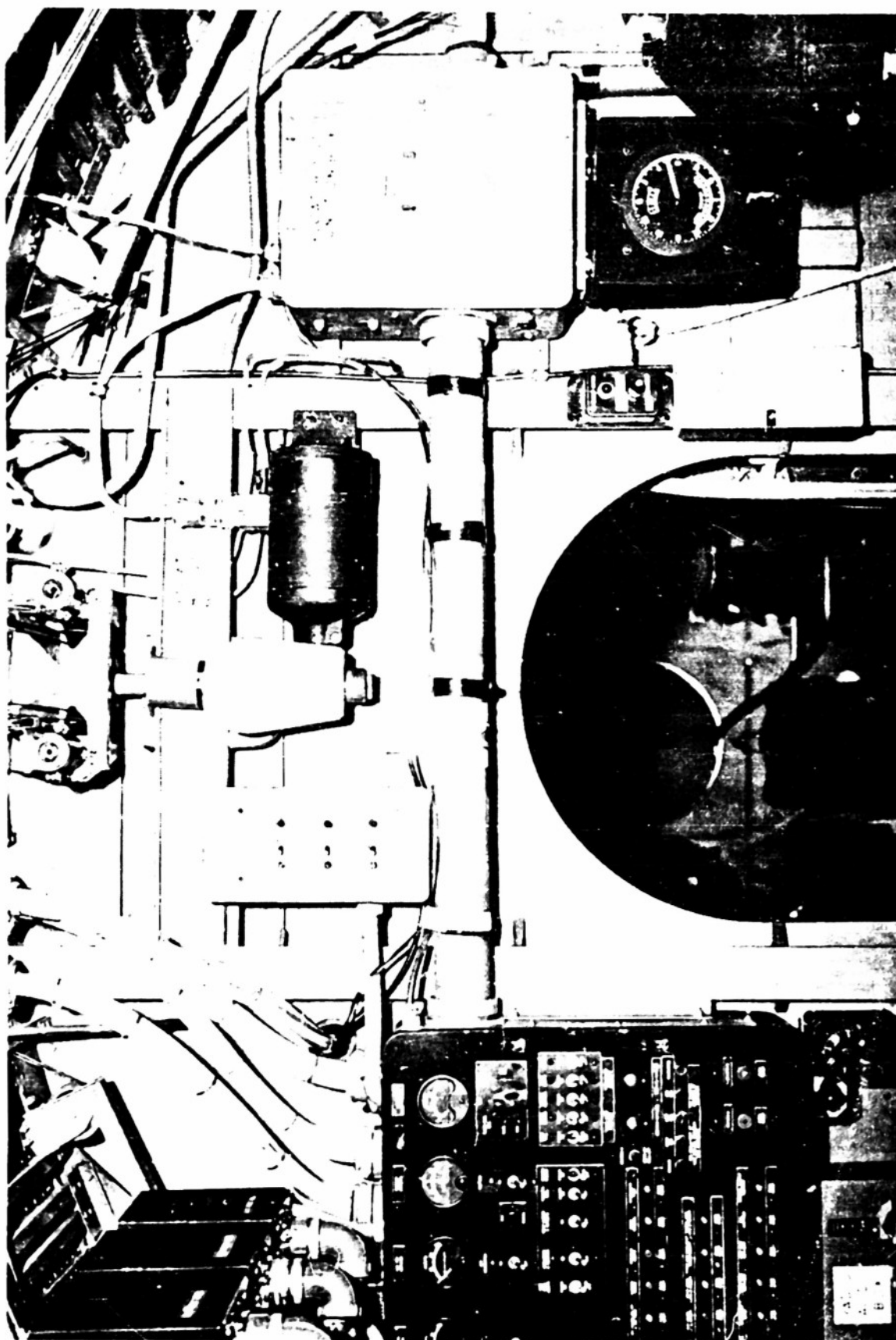
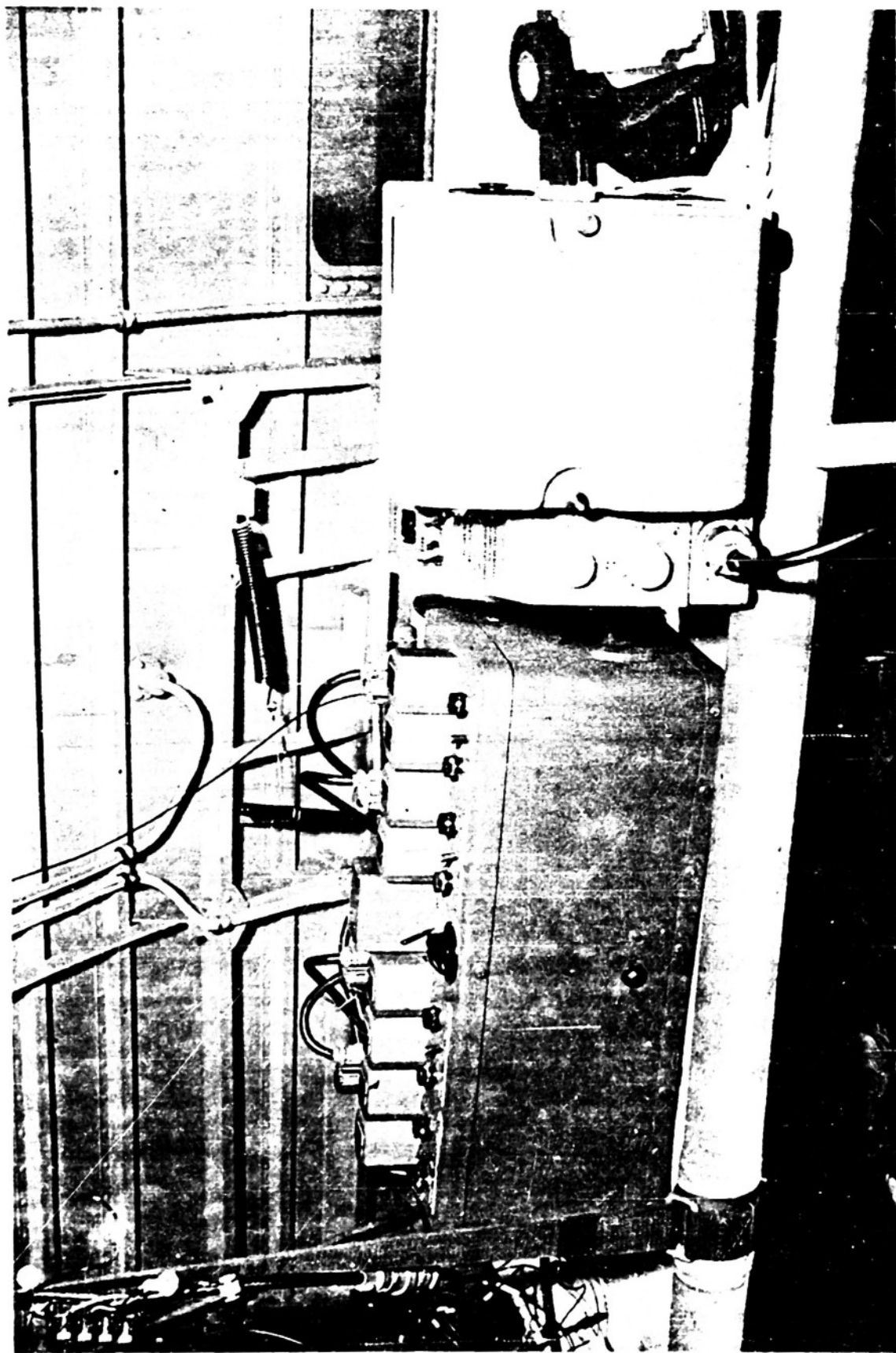VIEW OF PBY 6A-NAVY 46683

LIFT STRUTS SHOWING GAGES NO. 1 & NO. 3

GAGES NO. 5 & NO. 6, COVERED

FLIGHT I RECORDING INSTRUMENTS

6 G ACCELEROMETER

FLIGHT II RECORDING INSTRUMENTS

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APPENDIX NO. 2

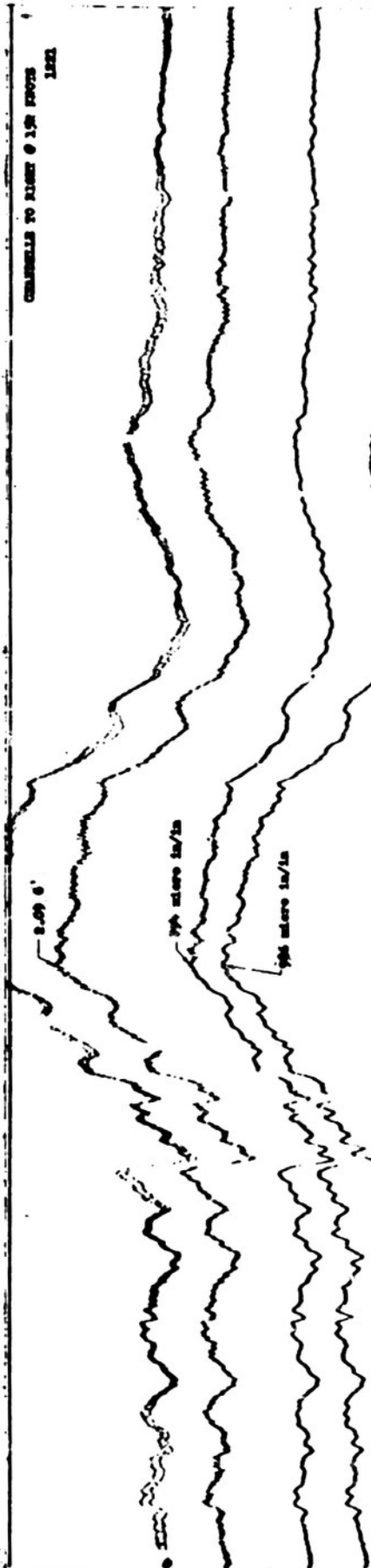## REPRODUCTIONS OF OSCILLOGRAPH RECORDS
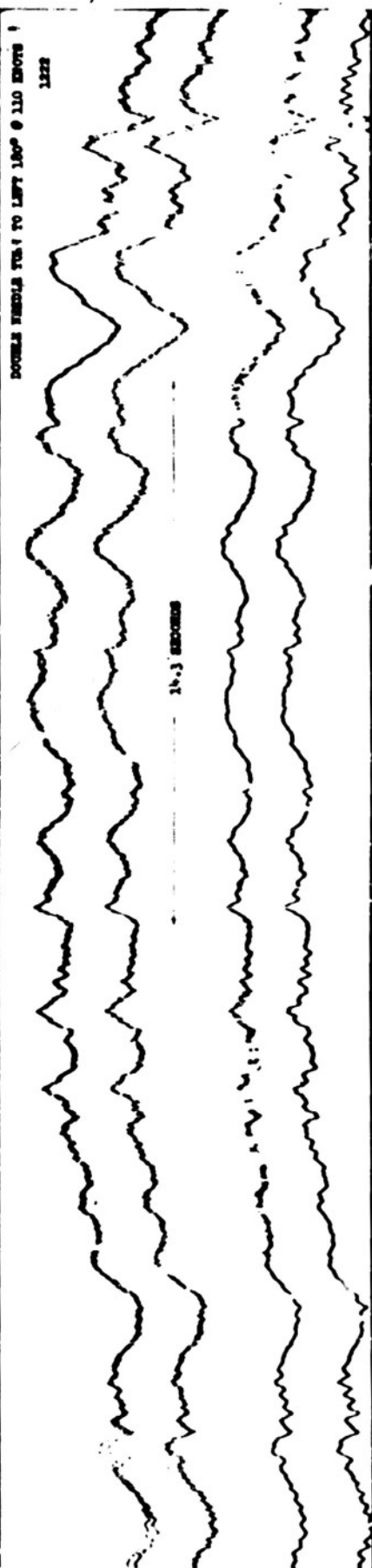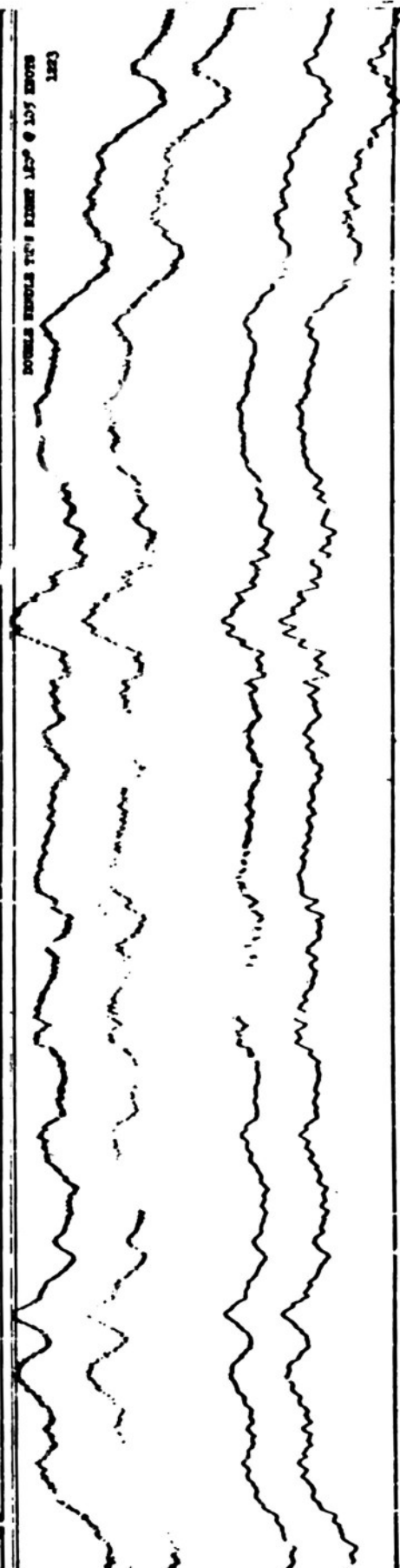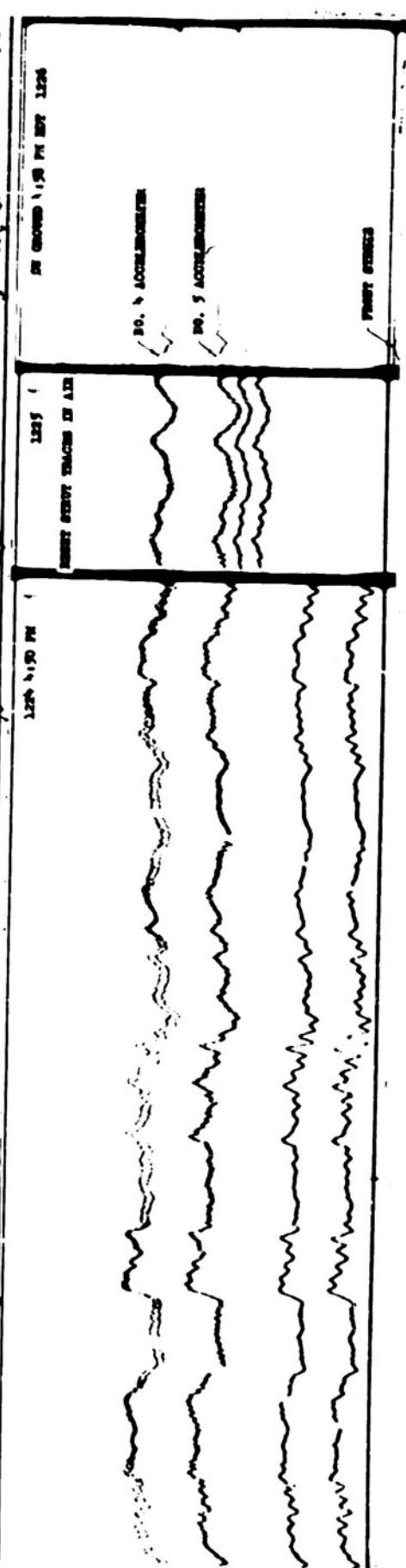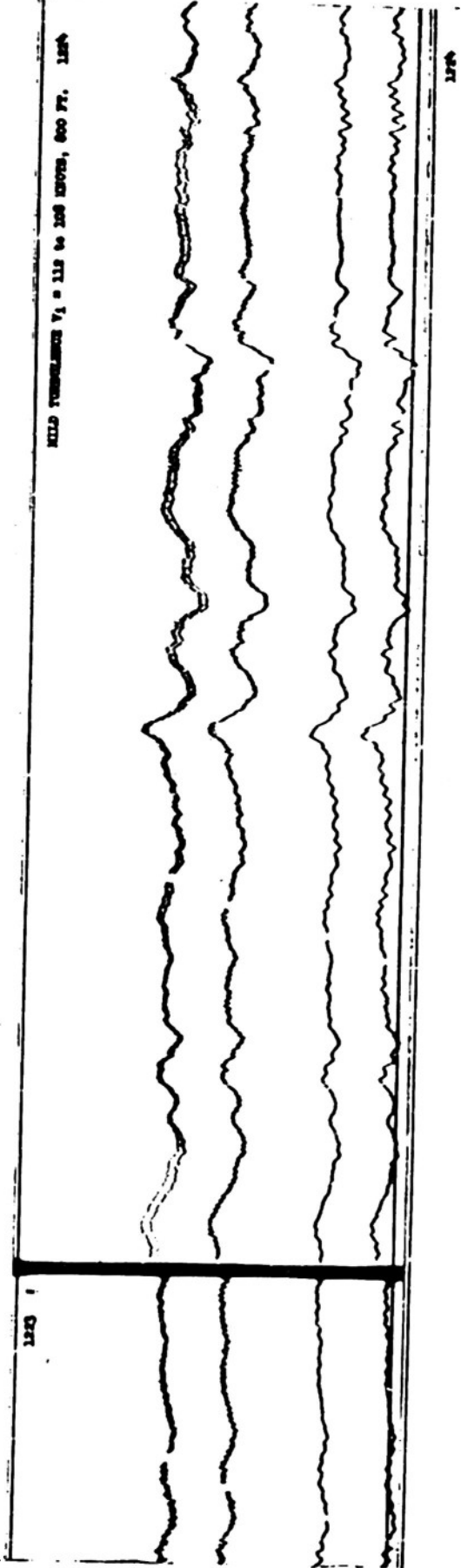
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APPENDIX NO. 3

WEIGHT AND BALANCE DATA

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TABLE I

WEIGHING PBY-6A, NAVY 46683 ON 9-6-52

TIME	WHEEL	JACK PRESSURE	WEIGHT	J. TRAVEL	θ
3:25 PM	Left Main	4750 psi	14850 Lbs	3.875"	1.1°
-	Right Main	4300	13430	3.938	1.1
4:02 PM	Nose Gear	825	2580	2.250	0.6

NOTES: 1. 464 gallons of gasoline @ 6 lbs/gal; 82 gallons of oil
@ 7.5 lbs/gal. aboard at this date.

2. No personnel aboard, magnetic towing reel aboard. L & N
Recorder and water column accelerometer in Navigation
compartment. Large box of tools in crew's quarters. Twin
channel L & N, amplifiers and homing coil usually in
blister compartment not aboard for this weighing.

3. Main wheel spacing ¢ to ¢ = 201 inches.

4. Jack load = Jack pressure x 3.125.

TABLE II

CALCULATING BASIC WEIGHT & CG LOCATION PBY-6A, NAVY 46683, 9-6-52

ITEM	WEIGHT	ARM	WEIGHT x ARM Lb-in
Left main	14850	273.3	4060000
Right main	13430	273.3	3678000
Nose gear	2580	68.4	176300
Fuel	-2785	267.0	-744000
Oil	-615	208.0	-128100
Total	27460 Lbs.		7042200 Lb-in

cg = 7042200/27460 = 256" inches.

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TABLE III

WEIGHT & BALANCE DATA PBY-6A, NAVY 46683 FROM AN-01-1B-40

ITEM	ARM-STATION
Nose wheel	68.4"
Pilot's Seats	113.0
Radar Seat	170.8
Navigation Table	170.8
Mechanics Seat	260.0
Main Wheels	273.3
Fuel	267.0
Trapped Oil	208.0
Crew's Quarters	351.3
Blister Compartment	425.0

Mean Aerodynamic Chord, M.A.C. = 165.3"

Most forward permissable cg = 23% MAC = 242.47"

Most aft cg limit, hydrodynamic = 33% MAC = 256.0"

Most aft cg limit controllability in flight = 34% MAC = 260.7"

Reference chart E AN-01-1B-40

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TABLE IV

WEIGHTS OF MISCELLANEOUS INSTRUMENTS

ITEM	WEIGHT
5-116 Consolidated Oscillograph	55.0 Lbs.
Opad-Green Rectifier	38.5
Four Channel, 1 Kc Amplifier	30.0
Large Tool Box (GAB)	15.4
Instrument Box (GAB)	6.2
SR-4 Strain Indicator	25.5
SR-4 Twenty Channel Switch	8.5
Speed Graphic Camera & Case	10.2
Experimental Pitot Tube	~10.0

NOTES: Instruments weighed on Chadwick & Carr balance scale,
inspected by H. Catlon New Bedford Department of Weights
and Measures September 1952

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TABLE V

WEIGHTS OF INDIVIDUAL CREW MEMBERS

PERSONNEL	WEIGHTS
N. Gingras	180 Lbs
R. Fournier	190
K. McCasland	140
L. Rose	180
A. Bunker	180
E. Miller	145
C. Kiernan	180
D. Leeper	180
G. Brewer	176

NOTES: Above weights are individual estimates.

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TABLE VI

COMPUTING WEIGHT AND BALANCE FLIGHT I; 9-8-52

ITEM	WEIGHT	ARM	WEIGHT x ARM
Airplane	27460 Lbs	256.0	7042200
Fuel, 464 gallons	2785	267.0	744000
Oil, 82 gallons	615	208.0	128100
N. Gingras	180	113.0	20350
R. Fournier	190	113.0	21500
D. Leeper	180	170.8	30720
A. Bunker	180	170.8	30720
C. Kiernan	180	170.8	30720
L. Rose	180	260.0	46800
E. Miller	145	351.3	50900
G. Brewer	176	351.3	61700
Strain Indicator	25.5	351.3	8960
SR-4 Switch	8.5	351.3	2950
Power Supply	38.5	351.3	13500
Pitot Tube	10.0	-36.0	-360
L & N plus Amplifiers	~155	425	65800
Two men	~330	425	140200
Total	32838.5		8438760

NOTES: 1. Take off 1:42 PM EDT, land 3:15 PM; fuel consumption
approximately 78 gph.

2. Time of strain gage records, 2:22 to 2:46PM, average
2:34 PM. Fuel consumed at this point 405 lbs (67.5 gal)
and 25 lbs oil. G.W. at time of test = 32408 lbs.

GIVEN BREWER
CONSULTING ENGINEER

TABLE VII

COMPUTING WEIGHT AND BALANCE FLIGHT II; 9-8-52

ITEM	WEIGHT	ARM	WEIGHT x ARM
Airplane	27460 Lbs	256.0	7042200
Fuel, 343 gallons	2060	267.0	550000
Oil, 76 gallons	570	208.0	118500
N. Gingras	180	113.0	20350
D. Leeper	180	113.0	20350
R. Fournier	190	170.8	32450
A. Bunker	180	170.8	30720
C. Kiernan	180	170.8	30720
L. Rose	180	260.0	46800
Tools (E. Miller)	-25	351.3	-8780
G. Brewer	176	351.3	61700
5-116 Oscillograph	55.0	351.3	19300
Power Supply	38.5	351.3	13500
Amplifier	30.0	351.3	10520
Tool Box	15.4	351.3	5400
Tool Box (Instrument)	6.2	351.3	2160
Camera & Case	10.2	351.3	3560
Pitot Tube	10	-36	-360
Total	31496.3		7999090

NOTES: 1. Take off 4:29 PM, land 4:58 PM, 9-8-52

2. Tests completed 15 minutes after take off, neglect weight change. Gross weight = 31496 Lbs, cg @ 254"

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TABLE VIII

CALIBRATING HEIN-WERNER 12 TON JACK, M.I.T. 9-16-52

DIAL PRESSURE PSI.	MACHINE LOAD LBS.	PISTON EXTENSION Inches.
0	0	0.25
500	1190	-
1000	2560	-
1500	4010	-
2000	5600	-
3000	8790	-
4000	11880	-
5000	15150	-
6000	18200	-
7000	21250	-
8000	24350	0.438
+ 5000	15700	1.75
+ 8000	25000	1.75

NOTES: 1. Hein-Werner 12 Ton Jack, model E 12.9A, 9 to 18" travel.

2. Jack cylinder pressure measured on Ashcroft 0-10000 psi pressure gage.

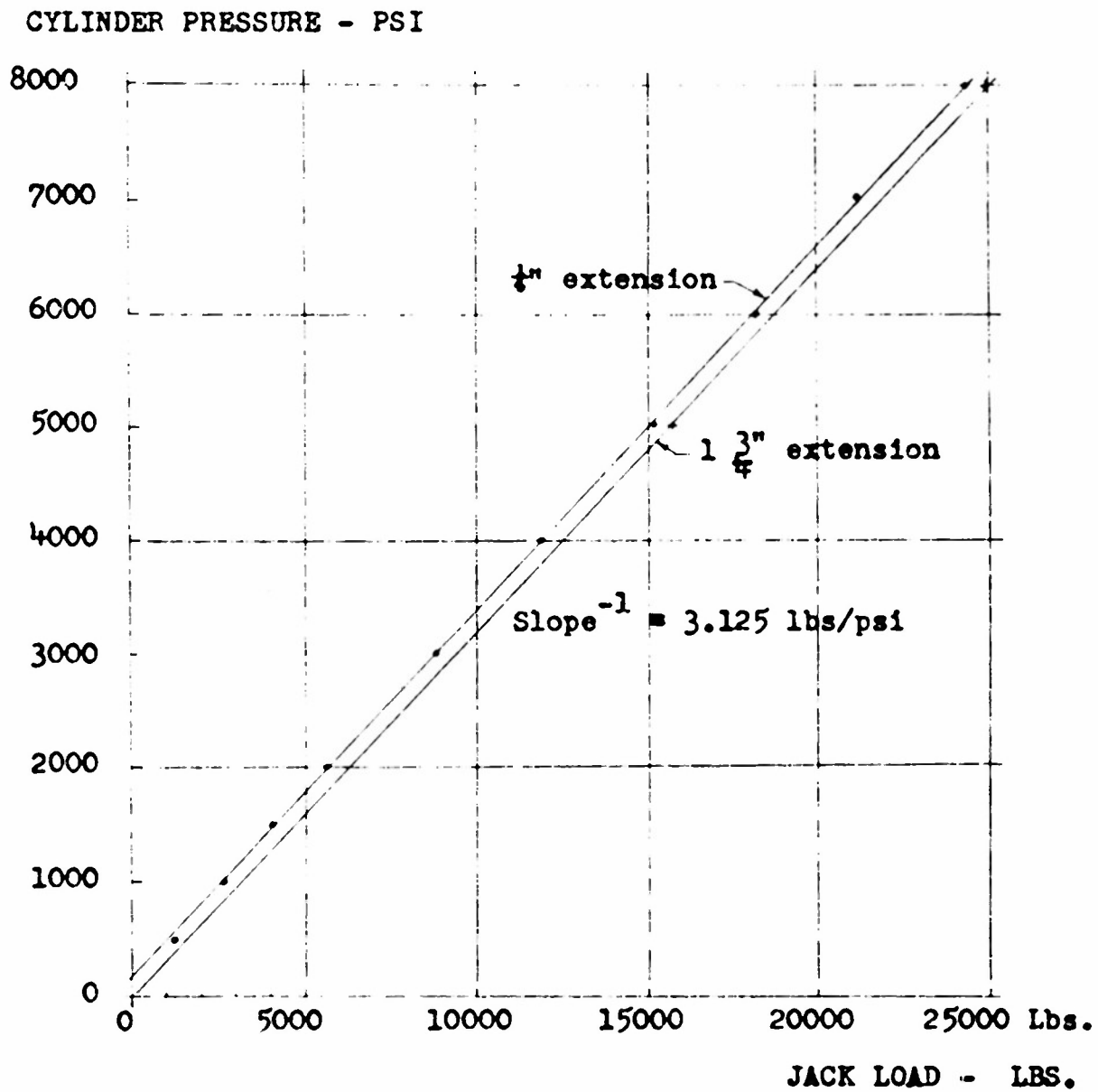3. Jack load measured on Tinius Olsen beam balance testing machine. Department of Mechanical Engineering M.I.T.

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CYLINDER PRESSURE - PSI

FIGURE 1.   PLOT JACK CYLINDER PRESSURE VS JACK LOAD.

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APPENDIX NO. 4

GAGE HISTORY

GIVEN BREWER
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TABLE I

SCHEDULE OF GAGE ATTACHMENT N 46683

GAGE NO.	TYPE	RESISTANCE	FACTOR	ATTACHED	COVERED
1	A-6	$300 \pm 1 \wedge$	$2.04 \pm 1\%$	9-5-52, 5:00P	9-6-52 8:30 AM
2	A-6	$300 \pm 1 \wedge$	$2.04 \pm 1\%$	5:10 PM	
3	A-6	$300 \pm 1 \wedge$	$2.04 \pm 1\%$	5:28 PM	-
4	A-6	$300 \pm 1 \wedge$	$2.04 \pm 1\%$	5:33 PM	-
5	A-6	$300 \pm 1 \wedge$	$2.04 \pm 1\%$	5:58 PM	-
6	A-6	$300 \pm 1 \wedge$	$2.04 \pm 1\%$	6:03 PM	-
7	A-6	$300 \pm 1 \wedge$	$2.04 \pm 1\%$	6:20 PM	9-6-52 5:00 PM
8	A-6	$300 \pm 1 \wedge$	$2.04 \pm 1\%$	6:25 PM	
D-1	A-6	$300 \pm 1 \wedge$	$2.04 \pm 1\%$	8:00 PM	9-6-52 8:30 AM

NOTES:
1. Gages glued to wing lift struts with SR-4 cement then after drying overnight covered with A-2 cement & activator. Then covered with rubber tape gages #5, #6, #7 & #8 and friction tape gages #1, #2, #3, #4 and D-1. Entire gage area of struts then wrapped with heavy corrugated cardboard and masking tape. Cardboard covered with 2-3 coats white shellac.

2. Gage leads doubled over and connected to #20 solid lead in wires using AMP 36551 fittings, three crimps.

3. Dummy D-1 had end metal to metal contact with front strut for thermal contact, remainder of dummy riding on masking tape to prevent mechanical connection with strut. Dummy was light aluminum alloy sheet metal channel, gage on web.

4. Lead in wires clamped to fuselage by sheet metal clips and screws. Wires protected from chafing at fuselage by means of rubber grommets through the skin.

5. September 5th. dry, sunny and warm.

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